We claim:

1. A monolithically fabricated apparatus comprising:

a doubly clamped, suspended beam with a submicron width having an asymmetrically positioned, mechanical-to-electrical transducing layer fabricated within or on the beam;

at least one side drive gate proximate to the beam within a submicron distance.

2. The apparatus of claim 1 where the asymmetrically positioned, mechanical-to-electrical transducing layer comprises an asymmetrically positioned piezoelectric layer within the beam.

3. The apparatus of claim 1 where the beam is fabricated from a 2 DEG heterostructure.

4. The apparatus of claim 1 wherein the beam is provided with electrical contacts and forms a two-terminal circuit with an output terminal, and further comprising an inductor in parallel circuit with the beam and a blocking capacitor coupled to the output terminal of the beam.

5. The apparatus of claim 4 further comprising a low noise cryogenic amplifier coupled to the blocking capacitor.

6. The apparatus of claim 1where the gate is provided with a gate dipole charge separation and where the beam is provided with a beam dipole charge separation, the beam and gate interacting through the dipole-to-dipole interaction.

7. The apparatus of claim 1 further comprising cryogenic means for maintaining the beam at cryogenic temperatures.

8. The apparatus of claim 1 wherein the side gate includes a 2 DEG layer.

9. The apparatus of claim 1 wherein the beam and side gate comprise a chip and further comprise a substrate on which the chip is disposed, the substrate having an electrode formed thereon, where the gate being provided with a gate dipole charge separation between the electrode of the substrate and the gate, and where the beam is provided with a beam dipole charge separation, the beam and gate interacting through the dipole-to-dipole interaction.

10. The apparatus of claim 1 where the beam and gate are fabricated from an asymmetric heterostructure stack comprising a 2 DEG GaAs piezoelectric layer, two sandwiching AlGaAs spacer layers on each side of the GaAs layer, a first and second AlGaAs: Si donor layer above and below the AlGaAs spacer layers respectively, two GaAs cap layers above and below the AlGaAs: Si donor layers respectively.

11. The apparatus of claim 10 where each of the layers below the 2 DEG GaAs piezoelectric layer is thicker than the corresponding layer above the 2 DEG GaAs piezoelectric layer.

12. The apparatus of claim 10 further comprising an $Al_xGa_{1-x}As$ sacrificial layer disposed under the stack and a substrate disposed under the $Al_xGa_{1-x}As$ sacrificial layer, where $0 < x < 1$.

13. The apparatus of claim 1 where the gate is provided with a gate dipole charge separation, and where the beam is provided with a beam dipole charge separation, the beam and gate interacting through the dipole-to-dipole interaction.

14. The apparatus of claim 13 further comprising two gates, each disposed within a submicron distance of the beam and each provided with a gate dipole charge separation.

15. The apparatus of claim 13 further comprising a source of sensing current supplied to the beam and an amplifier in circuit with the beam to generate an output signal.

16. The apparatus of claim 15 where the amplifier is cryogenic.

17. The apparatus of claim 15 where the source of sensing current supplies DC and AC sensing current to the beam.

18. The apparatus of claim 1 where the transducing layer of the beam is piezoelectric which is used to induce oscillation of the beam, and is also piezoresistive which is used to sense oscillation of the beam.

19. An improvement in a method of forming a suspended NEMS beam including a two-dimensional-electron-gas layer comprising:

providing a heterostructure stack including a 2 DEG layer disposed on a sacrificial layer;

selectively disposing a mask on the stack to define a pattern for the NEMS beam;

dry etching away exposed portions stack the using a Cl_2/He plasma etch to define the NEMS beam without substantially altering the electrical characteristics of the 2 DEG layer; and

etching the sacrificial layer away to release the NEMS beam.

20. The method of claim 19 where dry etching away exposed portions stack the using a Cl_2/He plasma etch comprises supplying Cl_2 and He gas at a flow rate ratio of 1:9 respectively into an ECR plasma chamber.

21. The method of claim 20 where supplying Cl_2 and He gas into the ECR plasma chamber further comprises maintaining the stack at or less than 150V self-bias with

20W constant RF power and ionizing the Cl_2 and He gas with approximately 300W microwave power or more.

22. A NEMS parametric amplifier comprising:

a suspended oscillating submicron signal beam defined in a plane and having a flexural spring constant for in-plane motion and being driven at ω at or near the frequency of mechanical resonance of the signal beam;

a pair of pump beams coupled to the signal beam and being driven at or near 2ω;

a source of magnetic field applying a field with at least a component perpendicular to the signal beam and pair of pump beams; and

a source of alternating current coupled in circuit with the pump beams to apply a current through the pump beams in the presence of the magnetic field to generate a modulated Lorentz force on the pump beams to apply in turn a force oscillating of compression and tension to the signal beam to perturb the flexural spring constant for in-plane motion of the signal beam.

23. The apparatus of claim 22 further comprising an amplifier coupled to the beam.

24. The apparatus of claim 22 where the pump beams and signal beam collectively form an H-shaped structure in the plane, the signal beam forming the middle portion of the H-shaped structure.

25. The apparatus of claim 22 where the pump beams are tuned to resonate at 2ω.

26. A method of operating a NEMS parametric amplifier comprising:

applying a magnetic field with at least a component perpendicular to a pair of pump beams;

supplying alternating current at a frequency of or near 2ω to the pump beams in the presence of the magnetic field to generate a modulated Lorentz force of compression and tension to the signal beam coupled to the pump beams to perturb the flexural spring constant for in-plane motion of the signal beam;

oscillating the signal beam in response to the driven pump beams at a frequency of ω which is at or near the mechanical resonant frequency of the signal beam; and

sensing signal beam oscillations.

27. The method of claim 26 further comprising providing the pump beams tuned to the frequency 2ω.

28. The method of claim 26 where the pump beams are driven in an opposing quadrature of phase relative to the oscillation of the signal beam.

29. A submicron cantilever characterized by a submicron displacement comprising:

a NEMS cantilever having a restriction portion;

a piezoresistive strain transducer epilayer coupled to the cantilever;

where G is the gauge factor of the apparatus given by

$$G = \frac{3\beta\pi_L K(2l - l_1)}{2bt^2} R_T$$

where the parameter π_L is the piezoresistive coefficient of the piezoresistive transducer material, the factor β accounts for the decrease in G due to the finite thickness of the conducting layer, K is the spring constant of the cantilever, l the overlength of the cantilever, l_1 the length of the restriction portion, b the thickness of the restriction portion, t the thickness of the thickness of the restriction portion, and R_T is two-terminal resistance of the transducer.

30. The cantilever of claim 29 where near resonance, force spectral density of thermomechanical fluctuations is given by

$$S_F^{\gamma} = 4k_B T\gamma = 4Kk_B T/(2\pi Q f_0)$$

where k_B is the Boltzman constant, T is the temperature, γ is the damping coefficient, f_0 is the resonance frequency and $Q=mf_0/\gamma$ is the quality factor, m is the mass of the cantilever.

31. The cantilever of claim 30 where near resonance, voltage spectral density for the thermomechanical fluctuations is given by

$$S_V^{\gamma} = \frac{S_F^{\gamma} G^2 l^2}{16\pi^2 m^2 f_0^2 [4(f-f_0)^2 + f_0^2/Q]}$$

where f is the frequency of oscillation of the cantilever.

32. A method for scaling and determining carrier distribution in NEMS devices having a doped layer with different doping concentration and different thicknesses disposed on an instrinsic layer comprising:

providing the doped layer with a predetermined thickness;

providing a doping concentration in the doped layer;

adjusting the Fermi level until charge neutrality is obtained by satisfying the condition

$$\int_0^{\ell}\left(\rho(x)/e+N_A^-(x)\right)dx=0$$

where

$$N_A^-(x)=\frac{\#dopants}{\frac{1}{2}e^{-\beta(E_A-(E_F-\varepsilon_V))}}$$

is the density of ionized acceptor sites, where ρ is volume density of carriers given by Fermi statistics, $\rho(x)=e(p(x)-n(x))$ and positive and negative carrier densities are

$$p(x)=1.04x10^{25}\,e^{-\beta(E_F-E_V)}\,/m^3$$

$$n(x)=2.8x10^{25}\,e^{-\beta(E_c-E_F)}\,/m^3$$

where β is 1/kT, E_F is the Fermi energy, E_V is the energy of the valence band energy, and E_C is the energy of conduction band;

determining the bending of the valence band according to the equation

$$\frac{d^2E_v}{dz^2}=\frac{e\rho(x)}{\varepsilon}$$

where E_v is the energy of the valence band, ε is the dielectric constant, e is the charge of the electron, subject to the boundary condition:

$$\left.\frac{d^2E_v}{dz^2}\right|_{z=0}=\frac{e\sigma}{\varepsilon}$$

where σ is the empirical surface carrier density; and

iteratively repeating the foregoing steps of adjusting and determining until convergence is attained for a carrier density, ρ.

33. A bridge circuit comprising;

a source of excitation signal;

a power splitter coupled to the source to generate two out-of-phase components of the excitation signal;

a first actuation port coupled to the power splitter;

a second actuation port coupled to the power splitter;

a first circuit arm coupled to the first actuation port including a first NEMS resonating beam having an transduced electrical output;

a second circuit arm coupled to the second actuation port including a second NEMS resonating beam having an transduced electrical output, the first and second beams being matched to each other; and

a detection port coupled to the DC coupling resistance, R_e *and* to the NEMS resonating beam.

34. The bridge of claim 33 further comprising a variable attenuator and a phase shifter coupled in circuit in opposing ones of the first and second circuit arms, the attenuator to balance out impedance mismatch between the first and second circuit arms more precisely than without the inclusion of the attenuator, while the phase shifter compensates for the phase imbalance created by the circuit inclusion of the attenuator.

35. The bridge of claim 33 where the NEMS resonating beam includes a surface adapted to adsorb a test material, performance of the NEMS resonating beam being affected by the test material and being measured by the bridge.

36. The bridge of claim 33 further comprising an amplifier and an output impedance mismatch circuit coupling the detection port to the amplifier.

37. The bridge of claim 33 where the first and second NEMS resonating beams are magnetomotive NEMS resonating beams and have no metallization.

38. A method of balancing the output of two NEMS devices in a bridge circuit comprising:

providing an excitation driving signal;

splitting the excitation driving signal into two out-of-phase components;

providing one of the out-of-phase components to a first NEMS resonating beam having a first transduced electrical output;

providing the other one of the out-of-phase components to a second NEMS resonating beam having a second transduced electrical output, the first and second beams being matched to each other; and

summing the first and second transduced electrical outputs together to generated a balanced detected output signal.

39. The method of claim 38 further comprising variable attenuating the driving excitation signal to one of the first and second NEMS resonating beams and providing a compensating phase shift in the driving excitation signal to the other one of the first and second NEMS resonating beams to balance out impedance mismatch between the first and second NEMS resonating beams more precisely than without attenuation or phase shift compensation for the phase imbalance created by the attenuation.

40. The bridge of claim 38 further comprising adsorbing a test material on the surface of the NEMS resonating beam to alter performance of the NEMS resonating beam and measuring the alteration of performance in the balanced detected output signal.

41. The method of claim 38 further comprising amplifying the balanced detected output signal in an amplifier, and impedance matching the output of a detection port on which the balanced detected output signal is provided with the amplifier.

42. The method of claim 38 further comprising providing a magnetic field in which the first and second NEMS resonating beams are exposed; driving the first and second NEMS resonating beams with a magnetomotive force without metallization on the first and second NEMS resonating beams.

43. The apparatus of claim 38 further comprising an adsorbing surface disposed on one of the NEMS resonating beams, wherein adsorption of an adsorbate on the adsorbing surface is indicated in the balanced detected output signal.

44. An apparatus comprising:

a driving source;

a power splitter coupled to the source for generating drive signals of opposing phases;

a first magnetomotive NEMS resonating beam coupled to one phase of the drive signal generated by the power splitter;

a second magnetomotive NEMS resonating beam coupled to the other opposing phase of the drive signal generated by the power splitter;

a terminal electrical coupled to the two magnetomotive NEMS resonating beams;

an amplifier coupled to the terminal; and

means coupled to the amplifier, the means for measuring the frequency dependence of the forward transmission coefficient S_{21} of the apparatus.

45. The apparatus of claim 44 where the first and second magnetomotive NEMS resonating beams are comprised of SiC.

46. The apparatus of claim 44 where the first and second magnetomotive NEMS resonating beams vibrate in an in-plane resonance.

47. The apparatus of claim 44 where the first and second magnetomotive NEMS resonating beams vibrate in an out-of-plane resonance.

48. The apparatus of claim 44 further comprising an adsorbing surface disposed on one of the NEMS resonating beams, wherein adsorption of an adsorbate on the adsorbing surface is measured by the means for measuring.

49. A method comprising:

providing an excitation driving signal;

splitting the excitation driving signal into two out-of-phase components;

providing one of the out-of-phase components to a first NEMS resonating beam having a first transduced electrical output;

providing the other one of the out-of-phase components to a second NEMS resonating beam having a second transduced electrical output, the first and second beams being matched to each other;

vibrating the first and second NEMS resonating beams;

summing the first and second transduced electrical outputs together to generated a balanced detected output signal;

amplifying the balanced detected output signal in an amplifier; and

measuring the frequency dependence of the forward transmission coefficient S_{21}.

50. The method of claim 49 where vibrating the first and second magnetomotive NEMS resonating beams comprises vibrating the beams at an in-plane resonance.

51. The apparatus of claim 49 where vibrating the first and second magnetomotive NEMS resonating beams comprises vibrating the beams at an out-of-plane resonance.

52. An improvement in a magnetomagnetically driven submicron NEMS resonating beam comprising:

a submicron SiC NEMS beam having a surface and an axial length L, width W, Young's modulus E, mass density ρ, and displacement amplitude A ;

a source of a magnetic field, B;

an electrode means disposed on the surface of the beam for conducting current along at least a portion of the axial length of the beam;

a source of alternating current coupled to a first end of the electrode means to magnetomotively drive the SiC NEMS beam to a resonant frequency $f_0 = \sqrt{\frac{E}{\rho}}\frac{W}{L^2}$; and

a detector coupled to a second end of the electrode means to detect a generated Vemf from the SiC NEMS beam of $V_{emf} \propto B\,A\sqrt{\frac{E}{\rho}}\frac{W}{L}$.

53. The improvement of claim 52 where the electrode means comprises a single electrode coupled to the source of alternating current for driving the beam in the magnetic field and coupled to the detector for sensing the EMF generated in the electrode by motion of the beam.

54. The improvement of claim 52 where the electrode means comprises a first electrode coupled to the source of alternating current for driving the beam in the magnetic field and a second electrode coupled to the detector for sensing the EMF generated in the electrode by motion of the beam.

55. The improvement of claim 52 where the SiC NEMS beam has dimensions and parameters providing a fundamental resonance frequencies in the UHF range and higher.

56. The improvement of claim 52 where the SiC NEMS beam has dimensions and parameters providing a fundamental resonance frequencies in the microwave L band.

57. A method of tuning a submicron NEMS device having an out-of-plane resonance comprising:

providing a magnetic field in which the NEMS device is positioned;

supplying an AC current to the NEMS device to oscillate the NEMS device in the magnetic field at a resonant frequency;

supplying a DC current to the NEMS device to tune the out-of-plane resonant frequency of the NEMS device with a constant Lorentz force.

58. The method of claim 57 where the NEMS device has an axial length and is provided with a metallization along its axial length, where supplying a DC current to the NEMS device comprises supplying a DC current to the metallization.

59. The method of claim 57 where the NEMS device also has an in-plane resonance and further comprising varying the temperature of the NEMS device to tune both the out-of-plane and in-plane resonance of the NEMS device.

60. A tunable submicron NEMS device having an out-of-plane resonance comprising:

a source of a magnetic field in which the NEMS device is positioned;

an AC current source coupled to the NEMS device to oscillate the NEMS device in the magnetic field at a resonant frequency;

a DC current source coupled to the NEMS device to tune the out-of-plane resonant frequency of the NEMS device with a constant Lorentz force.

61. The NEMS device of claim 60 where the NEMS device has an axial length and is provided with a metallization along its axial length, where the DC current source coupled to the NEMS device supplies a DC current to the metallization.

62. The NEMS device of claim 60 where the NEMS device also has an in-plane resonance and further comprising means for varying the temperature of the NEMS device to tune both the out-of-plane and in-plane resonance of the NEMS device.

63. The NEMS device of claim 62 where the NEMS device comprises a semiconductor-metal bilayer formed of a single crystalline highly doped semiconductor and the metallization disposed thereon is a polycrystalline metal to reduce stresses in the semiconductor-metal bilayer.

64. An improvement in a resonating submicron one-port NEMS device comprising a resonating beam having a width w, a thickness t, a length L, a detector load resistance R_L, an equivalent mechanical impedance R_m, operating a frequency corresponding to the wavelength λ with an electrode on the beam with a conductivity of σ such that the insertion loss ε defined as:

$$\varepsilon_1 = \frac{\alpha^2}{(1+\alpha)(1+\alpha+\frac{R_m\lambda\sigma tw}{L})}$$

where $\alpha = \dfrac{\lambda\sigma R_L tw}{L}$

is minimized or near unity.

65. An improvement in a resonating submicron two-port NEMS device comprising a resonating beam having a width w, a thickness t, a length L, a detector load resistance R_L, an equivalent mechanical impedance R_m, operating a frequency corresponding to the wavelength λ with an electrode on the beam with a conductivity of σ such that the insertion loss ε defined as:

$$\varepsilon_2 = \frac{1}{2}\alpha^{\frac{1}{2}}\left(\frac{1-\alpha}{1-.75\alpha}\right)^{\frac{1}{2}}$$

where $\alpha = \dfrac{\lambda\sigma R_L tw}{L}$

is minimized or near unity.

66. An improvement in a two-port, straight, doubly clamped NEMS magnetomotive beam coupled to an amplifier with a load resistance R_L, the NEMS beam having a length L, a thickness t, a width w, Young's modulus E, mass density ρ, in a magnetic

field B, with a conductivity σ of its metallization, a temperature T, a driving signal wavelength of λ, a resonant frequency of f_0, an amplifier spectral power density S^a_V, chosen so that the spectral displacement sensitivity $S^m_{X(2)}$ is equal to or greater than the spectral displacement density corresponding to thermal fluctuations of the NEMS beam, which spectral displacement sensitivity $S^m_{X(2)}$ is defined as

$$\sqrt{S^m_{X(2)}} = \frac{1.68}{\sigma^{\frac{1}{2}}\lambda^{\frac{1}{2}}B}\left(\frac{\rho}{E}\right)^{\frac{1}{8}} f_0^{-\frac{3}{4}} t^{-\frac{3}{4}} w^{-\frac{1}{2}}\left[k_B T + \frac{S_V^a}{R_L}\left(\frac{1-0.75\alpha}{1-\alpha}\right)\right]^{\frac{1}{2}}$$

where k_B is the Boltzman constant and

$$\alpha = 0.99 R_L \sigma\lambda\left(\frac{\rho}{E}\right)^{\frac{1}{4}} f_0^{\frac{1}{2}} t^{\frac{1}{2}} w.$$

67. A method for fabrication of a NEMS beam from a Si membrane comprising:

providing a Si substrate;

disposing a SiO_2 layer on the Si substrate;

disposing a Si epilayer on the SiO_2 layer;

selectively anisotropically etching away a portion of the Si substrate down to the SiO_2 layer used as a stop layer;

selectively etching away a portion of the SiO_2 layer to expose a suspended Si epilayer membrane; and

forming the NEMS beam in the suspended Si epilayer membrane

whereby capillary distortion is avoided and electron beam resolution is achieved without proximate scattering from a substrate.

68. A method for fabrication of a NEMS beam from a GaAs membrane comprising:

providing a GaAs substrate;

disposing an AlGaAs layer on the GaAs substrate;

disposing a GaAs epilayer on the AlGaAs layer;

selectively anisotropically etching away a portion of the GaAs substrate down to the AlGaAs layer used as a stop layer;

selectively etching away a portion of the AlGaAs layer to expose a suspended GaAs epilayer membrane; and

forming the NEMS beam in the suspended GaAs epilayer membrane.

69. The method of claim 68 where selectively anisotropically etching away a portion of the GaAs substrate down to the AlGaAs layer used as a stop layer comprises etching with a NH_4OH or citric acid solution.

70. The method of claim 69 where etching with a NH_4OH solution comprises etching with a solution comprised of NH_4OH and H_2O_2 in the volume ratio of approximately 1:30, freshly mixed prior to etching.

71. The method of claim 69 where etching with a citric acid solution comprises etching with a room temperature bath comprised of citric acid monohydrate mixed and completely dissolved in a 1:1 mixture with deionized water by weight, then mixing this 1:1 mixture in a 3:1 volume ratio with H_2O_2 to provide the bath.

72. A NEMS array analyzer comprising:

two opposing parallel substrates;

a plurality of piezoresistive NEMS cantilevers extending from one of the substrates, each of the NEMS cantilevers having a different resonant frequency so that the corresponding plurality of resonant frequencies covers a selected spectral range; and

a plurality of drive/sense elements extending from the other one of the substrates, each of the drive/sense elements primarily coupled with one of the plurality of piezoresistive NEMS cantilevers.

73. A NEMS array analyzer comprising:

a frame;

a plurality of NEMS structures forming an interacting array to form an optical diffraction grating;

means for driving the plurality of NEMS structures in response to an input signal; and

light source for illuminating the plurality of NEMS structures; and

detector means for detecting diffracted light from the plurality of NEMS structures acting collectively as a time-varying diffraction grating.

74. A NEMS electronic chemical sensing array comprising:

a plurality of strain-sensing NEMS cantilevers, each having an overlayer disposed thereon which is responsive to a corresponding analyte, the response of the overlayer imposing a strain on the corresponding cantilever; and

means for detecting the strain of each of the plurality of strain-sensing NEMS cantilevers.

75. The NEMS electronic chemical sensing array of claim 74 where the response of the overlay comprises expansive or contractile volume changes of the overlay causing a strain to be imposed on the corresponding cantilever to cause it to bend, and where the means for detecting comprises an optical detector array for determining the amount of bending of each cantilever.

76. The NEMS electronic chemical sensing array of claim 74 where the response of the overlay comprises a mass loading resulting in a change in total inertial mass of each corresponding cantilever and where the means for detecting comprises means for detecting changes in resonant frequency shifts for each cantilever.

77. A NEMS infrared sensing array comprising:

two opposing parallel substrates;

a plurality of identically sized piezoresistive NEMS cantilevers extending from one of the substrates, each of the cantilevers being provided with a corresponding IR absorber responsive to a different IR frequency and inducing a corresponding differential thermal expansion of each cantilever depending on the amount of IR absorbed by each IR absorber; and

a plurality of drive/sense elements extending from the other one of the substrates, each of the drive/sense elements primarily coupled with one of the plurality of piezoresistive NEMS cantilevers.

78. A piezoresistive NEMS device with a confined carrier region comprising:

a doped semiconductor layer; and

an intrinsic semiconductor underlying the doped semiconductor wherein the thickness of the doped and instrinsic layers are as thin as approximately 7nm and approximately 23 nm respectively while retaining a well confined conducting layer.

79. A piezoresistive NEMS device with a confined carrier region comprising:

a doped semiconductor layer in which a quantum well is defined; and

an intrinsic semiconductor underlying the doped semiconductor, the thickness of the doped semiconductor layer and underlying intrinsic layer being reduced, until a predetermined magnitude of thickness for a depletion layer at the interface between the doped and intrinsic layers, and at the top surface of the doped layer is just allowed with a difference in band edge energy on the order of 0.4eV or greater being established at the interface.

80. The piezoresistive NEMS device of claim 79 further comprising a confining layer having a difference in band edge energy on the order of 0.4eV or greater with respect to the doped semiconductor layer disposed adjacent to the doped semiconductor layer.

81. The piezoresistive NEMS device of claim 80 further comprising a confining layer adjacent and underlying the doped semiconductor layer, and a confining layer adjacent and overlying the doped semiconductor layer, each confining layer having a difference in band edge energy on the order of 0.4eV or greater with respect to the doped semiconductor layer.

82. A piezoresistive NEMS device with a confined carrier region comprising:

a doped semiconductor layer in which a quantum well is defined; and

an insulating underlying the doped semiconductor, the thickness of the doped semiconductor layer and underlying insulating layer being reduced, until a predetermined magnitude of thickness for a depletion layer at the interface between the doped and insulating layers, and at the top surface of the doped layer is just allowed with a difference in band edge energy on the order of 0.4eV or greater being established at the interface.

83. A method of providing a piezoresistive transducer of minimal thickness while still retaining a piezoresistive characteristic comprising reducing the thickness of a doped semiconductor layer and reducing an underlying intrinsic layer, until a predetermined magnitude of thickness for a depletion layer at the interface between the doped and intrinsic layers, and at the top surface of the doped layer is just allowed.